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DESENVOLVIMENTO DE UMA SISTEMA PARA AVALIACAO DE EQUILIBRIO CORPORAL USANDO A PLATAFORMA KINECT

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RESUMO: Os principais métodos usados para avaliar doenças que causam problemas de balanço corporal são o Teste de Romberg e a Escala de Equilíbrio de Berg. Estas verificações são influenciadas por exercícios e a análise do balance depende da experiência do fisioterapeuta. Para melhorar o processo, um sensor Kinect da Microsoft foi usado para monitorar todas etapas dos testes. A integração desta tecnologia, associada com os testes, permitiu diagnósticos mais assertivos. Usando o Kinect e a programação desenvolvida, foi possível identificar o corpo humano e seus membros, e assim foi possível ler os movimentos do corpo em tempo real, bem como criar um gráfico da angulação do corpo, enquanto se fazia o teste. Além disso, o desenvolvimento de uma interface permitiu ao fisioterapeuta logar-se e cadastrar o paciente, bem como a verificação dos gráficos criados, ao longo do tempo de tratamento. Foram realizados dezenas de testes com pacientes entre 18 e 65 anos, com e sem sintomas patológicos. Para cada um deles, gráficos foram gerados, permitindo identificar as curvas características no Teste de Romberg e na Escala de Equilíbrio de Berg.

PALAVRAS-CHAVE: EQUILÍBRIO CORPORAL, KINECT, ESCALA DE EQUILÍBRIO DE BERG, TESTE DE ROMBERG

DEVELOPMENT OF A KINECT-BASED SYSTEM FOR EVALUATING BODY IMBALANCE

ABSTRACT: *The main methods used to evaluate diseases that cause body imbalance are made through Romberg's Test or Berg Balance Scale. These verifications are affected by exercises and the imbalance analysis' depends on the physiotherapist's experience. To improve this process, a Kinect sensor from Microsoft was used to monitor all the stages of the trials. The integration of this technology associated with the tests allows more assertive diagnosis. The use of Kinect and the developed programming was able to identify the human body with all its limbs and therefore possible to read the body movements in real time and create the graphic of body angulation still during the test. Besides that, the development of the interface allowed the physiotherapist's login, the input of the patient's information, and the verification of the created graphics. Dozens of tests were done, with patients from 18 to 65 years old, with and without symptoms of pathology. For each one of them the graphics were generated allowing identification of the characteristic curve in the Romberg's Test and Berg Balance Scale.*

KEYWORDS: BODY BALANCE, KINECT, BERG BALANCE SCALE, ROMBERG'S TEST

1. INTRODUCTION

To evaluate body balance two main tests are used: Romberg's Test and Berg Balance Scale, which are describe ahead. They depend on the physical therapist experience, and to improve the tests, a Kinect sensor which captures images, from the Microsoft's XBOX videogame system. The system was interfaced to a computer, and programs to detect body limbs and its movements were created, as well as a database to store the patients' tests an, creating graphics to help the expert analyze the results.

1.1 Romberg's Test

The Romberg's Test was developed by German neurosurgeon Moritz Heinrich Rom-berg (1795-1873). Romberg's idea had the intent to evaluate the condition of the patient's body imbalance. The test must be performed on a smooth surface, while the patient stands upright, barefoot, with arms parallel to the body and with eyes open. (FILHO, 2013).

In a second moment the same sequence is repeated with the closed eyes. Each instance of the test should take approximately sixty seconds. The result of the test is considered positive when there are signs of body imbalance (FILHO, 2013).

There is also Tandem or Sharpened Romberg, in this case the sequences are repeated with the same stances of Romberg's Test but with the addition that the feet are positioned one ahead of the other, figure 1 (FILHO,2013).

FIGURE 1. Correct position during Romberg's Test, developed by the authors (2017)

1.2 Romberg's Test

In 1992, Katherine Berg developed the Berg Balance Scale, to evaluate the imbalance of patients. The test is divided in fourteen steps and they contemplate activities like: sitting, stretching, moving, among others. In the end of the activities, a score is related to each activity

according to the performance achieved. The final score can vary between 0 to 56 points (RODINI, 2008).

The fourteen steps are available below; the first three are referring to static balance and the remaining to dynamic balance (FRANCO, 2011):

- Test A: The patient begins the test sitting on a chair and gets up without using their hands.
- Test B: The patient has to stand up for two minutes without support.
- Test C: The patient should try to sit without back support and then cross their arms for two minutes.
- Test D: The patient stands up then they should sit on the chair again.
- Test E: The patient is sitting on a chair, after that he (she) should stand up and sit on the chair again.
- Test F: The patient should stand up for ten seconds.
- Test G: The patient should stand up and place their feet side by side for ten seconds.
- Test H: The patient stands up, then position themselves beside a wall. With their spine straight, the patient must extend their arms and fingers and the physiotherapist will mark on the wall the initial position of the tips of the fingers, the patient should then bend their spine as much as then can, the physiotherapist marks the new position of the fingertips and compare it to the starting mark distance.
- Test I: the patient should pick up an object on the floor (tennis ball for example).
- Test J: The patient stands up, incline their neck to the right, back to the initial position and then they must perform the same motion to the left.
- Test K: The patient stands up and rotates 360° around its own axis. First to the right and then to the left.
- Test L: The patient should place their feet alternately on a small object (like a little box) placed on the floor.
- Test M: The patient stands up and puts one foot in front of the other for thirty seconds.
- Test N: The patient should remain standing on one leg (they can choose which) as long as possible.

2. MATERIALS AND METHODS

A program was created to detect the limbs and its movements in the image, and to store patient's data and from the corresponding tests. It used using C# language for PC (C sharp) and the Kinect API (application program interface), a library of functions from Microsoft to access the sensor.

2.1 Operation of the programming developed thought the Kinect platform

Main windows developed

When the software is initialized the first screen shown is for the login of the physiotherapist, Figure 2. If the user leaves some field blank the message "Please, complete all fields" is shown, if the use or the password is incompatible the message "User not registered" is shown. To ensure the safety of all data and the system access, only enabled users can register new users. The screen generated for the registration of the physiotherapist is shown in the image 4b.

FIGURE 2. Initial screen of login and register, developed by the authors (2017)

After login, the main window (Figure 3) opens automatically, allowing access to registration, inquiry and initialization of new tests.

FIGURE 3. Main access window, developed by the authors (2017)

Selecting the option “Register (Cadastrar in Portuguese)” the access menu (Figure 4) is reproduced, and the shown files must be completely filled in for the message “Data successfully registered” to be shown. Otherwise the message shown is “Please, fill all fields”.

FIGURE 4. Patient registry, developed by the authors (2017)

Patients already registered can be consulted, edited and deleted through the menu below (Figure 5).

Codigo	Usuario	Nome	Sexo	Endereco	DataNasc	Telefone
6	mcamilabf	Maria Cam...	Feminino	R: Dona Deolinda Pereira de ...	21/12/1991	(67) 98131-6970
7	Ever	Eveton Ca...	Masculino	R: Rua das couves	01/11/1993	(67) 99889-6648
8	Iguilherme	Luiz Guilh...	Masculino	R: Vida Loka Forever	06/04/1994	(67) 99820-7275
9	mari-rs	Marildes B...	Feminino	R: Cordilheira dos Andes	26/03/1970	(67) 99260-5262

Consulta

FIGURE 5. Patient consultation, developed by the authors (2017)

The last window, (Figure 6) was created for the tests with the patients. The developed interface presents to its left a space reserved to reproduce the images in real time with addition of a digital skeleton next to the human body. On the right there is a graph of the angulations as a function of time. A button to move the camera was created to facilitate adjustments. When the “Romberg” button is pressed a counter is activated, the skeleton is generated and the graphics are produced. When the counter reaches thirty seconds, a capture of the graph is made. Afterwards, within another thirty seconds another capture is made and both images are stored in the data base. When the counter reaches one minute, the camera and the graphic are stopped. On “EEB” button there is no counter, the shooting and the graphic are reproduced until the button “Finish (Encerrar in Portuguese)” is pressed.

FIGURE 6. Test screen, developed by the authors (2017)

2.2 Performed tests – developed phases

For the realization of this project and for the correct execution of the evaluation, instructions from the Physiotherapy and Neurology team of the Clinic of Universidade Católica Dom Bosco (UCDB) were followed. This project was inserted within the program of Integrated Physiotherapy Technology by the teacher Mr. Serginaldo José dos Santos, because he already had approval of the Institutional Review Board of Brazil (IRB) (CEP – “comitê de ética em pesquisa”).

The tests performed were divided in six steps, being four destined to Rom-berg’s Tests and two to Berg Balance Scale, the following are the sequences per-formed by patients:

1. Romberg’s Tests: The patient stands upright, barefoot, with arms parallel to the body and with eyes open for sixty seconds.
2. Romberg’s Tests: The patient stands upright, barefoot, with arms parallel to the body and with closed eyes for sixty seconds.
3. Romberg’s Tests: The patient stands upright, barefoot, eyes open, with the addition that the feet are positioned one ahead of the other for sixty seconds. (See figure 1).
4. Romberg’s Tests: The patient stands upright, barefoot, closed eyes, with the addition that the feet are positioned one ahead of the other for sixty seconds. (See figure 1).
5. Berg Balance Scale: The patient stands up and rotates 360° around its own axis. First to the right and then to the left (Test K).
6. Berg Balance Scale: The patient should place their feet alternately on a small object (like a little box) placed on the floor (Test L).

3. RESULTS AND CONCLUSIONS

To obtain the graphs ahead (Figures 7 to 12), the tests were performed in two patients, the first one (A1), had no diagnosis of any pathology of imbalance. The second patient (B2) had a diagnosis of inflammation in the labyrinth. The table (table 2) shows the information for analysis and comparison of the patients who performed the tests. Below are the results of the six tests performed.

TABLE 1. Data for criteria of analysis of patients, developed by the authors (2017)

	Patient A1	Patient B1
Age	23	22
Height	1.65	1.83
Sex	male	male

Source: Authors (2017)

FIGURE 7. Patient with pathology vs. patient without pathology, developed by the authors

FIGURE 8. Patient with pathology vs. patient without pathology, developed by the authors (2017)

FIGURE 9. Patient with pathology vs. patient without pathology, developed by the authors (2017)

FIGURE 10. Patient with pathology vs. patient without pathology, developed by the authors

FIGURE 11. Patient with pathology vs. patient without pathology, developed by the authors (2017)

FIGURE 12. Patient with pathology vs. patient without pathology, developed by the authors (2017)

Differences in graph curves are generated by the difference in height between patients (A1 1.65 m and B2 1.83m); however this doesn't affect the final result in the formation of the characteristic curve.

The integrated imbalance analysis using Kinect is a promising new proposal, because it decreases the time of the test reducing its execution, eliminating the need for repetitions (the graphs are stored and can be consulted) on uncertainties in results and specially to reduce the chance of misdiagnosis.

Although the development of the software has been completed, it has not yet been tested by health experts. With the completion of this project many other discoveries can be made, for example, the determination of the maximum and minimum curves that can be considered normal. It's also feasible to find out the level of imbalance according to the variation of the amplitude of the curves, however for such definitions to be made, tests must be done with a large number of patients (around one thousand) to carry out the tests.

Finally, the use of the proposed system is considered as a useful facilitator of the daily routine of the physiotherapist favoring the development of their work and making the examination of the common patient more accurate and less time-spending.

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